

REMARKS

The Examiner's Office Action of January 14, 2005 has been received and its contents reviewed. Applicants would like to thank the Examiner for the consideration given to the above-identified application.

By the above actions, claims 1, 2, and 6 have been amended. Support for the amendments can be found, for example, on page 3, line 12, to page 4, line 9. Accordingly, claims 1-10 are pending for consideration, of which claims 1, 2 and 6 are independent. In view of these actions and the following remarks, reconsideration of this application is now requested.

On page 2 of the Office Action, claim 1 stands rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,211,065 to Xi et al. (hereinafter Xi) and claims 2-5 are rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,057,239 to Wang et al. (hereinafter Wang) in view of Xi and U.S. Patent No. 6,057,247 to Imai et al. (hereinafter Imai).

On page 4 of the Office Action, claim 6 stands rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,104,092 to Matsubara et al. (hereinafter Matsubara); claims 7, 8 and 10 are rejected under 35 U.S.C. §103(a) as being unpatentable over Matsubara in view of U.S. Patent No. 5,277,750 to Frank; and claim 9 is rejected under 35 U.S.C. §103(a) as being unpatentable over Matsubara in view of Frank further in view of U.S. Patent No. 6,136,211 to Qian et al. (hereinafter Qian). In view of the amendments above and the comments that follow, Applicants respectfully traverse these rejections.

In accordance with an exemplary embodiment of the present invention as set forth in claim 1, for example, a method is provided for fabricating a semiconductor device that includes a step of depositing a fluorine-containing organic film having a relative dielectric constant of 4 or less on a semiconductor substrate using a material gas, the material gas being selected from gases composed of fluorine and carbon and containing C₄F₆, of which global warming potential is less than 100, as a main component.

The fluorine-containing organic film is deposited using the material gas which is selected from gases composed of fluorine and carbon and contains as a main component C₄F₆, having a global warming potential of less than 100. As a result, the semiconductor device fabricating method of the present invention can be significantly prevented from

causing global warming. In addition, as described in the present specification, by selecting a material gas containing C₄F₆ as a gas for film deposition, the amount of fluorine atoms within the fluorine-containing organic film is increased and thus a fluorine-containing organic film having a small relative dielectric constant can be achieved as compared to films deposited using conventional gases such as C₂F₆ and C₄F₈. Furthermore, the amount of free fluorine atoms contained in the film deposited by the present invention is less than that in fluorine-containing organic films deposited by using conventional gases such as CF₄, C₂F₆, C₂F₈ and C₄F₈. Thus, a fluorine-containing organic film having a more superior adhesion to the underlying film, as compared to the conventional films, can be obtained.

The Xi patent, on the other hand, discloses a deposition method of an amorphous fluorocarbon film having a low relative dielectric constant using a fluorine source gas such as CF₄, C₂F₂, C₃F₈ or C₆F₆. However, Xi fails to explicitly disclose or suggest using a material gas containing C₄F₆ as a film depositing gas and, thus, is different from the present invention.

In the Office Action, the Examiner further pointed out that in column 10, lines 58-64, Xi discloses that other fluorine source can be used as long as the atomic ratio of F:C available in the chamber remain less than 2. However, Xi fails to disclose selecting a gas to be used for film deposition for preventing global warming caused by the gas discharged during the deposition of the amorphous fluorocarbon film, as now set forth in the claims. In fact, Xi also completely fails to disclose the material gas being selected from gases composed of fluorine and carbon and containing C₄F₆, of which global warming potential is less than 100, as a main component. Hence, Applicants submit that Xi fails to explicitly disclose or suggest a specific gas selected from other material gases as a fluorine source gas. For the foregoing reasons, claim 1 of the present application is patentable over Xi.

In accordance with another exemplary embodiment of the present invention, as set forth in claim 2, a method for fabricating a semiconductor device is provided. An insulating film is dry-etched on a semiconductor substrate using an etching gas, the etching gas being selected from gases composed of fluorine and carbon and containing C₄F₆, of which global warming potential is less than 100, as a main component. A fluorine-containing organic film having a relative dielectric constant of 4 or less is deposited on the semiconductor substrate using a material gas. The material gas is selected from gases composed of fluorine and carbon and containing C₄F₆, of which global warming potential is less than 100, as a main

component. Also, the step of dry-etching an insulating film and the step of depositing a fluorine-containing organic film are performed in a same plasma processing apparatus.

The Wang patent, on the other hand, discloses plasma etching a second oxide film 12 to form a contact hole 32 in Fig. 3B, and the possibility of depositing a low relative dielectric constant material as a sacrificial layer 40 in Fig. 3C. However, Applicants respectfully submit that Wang fails to specifically disclose the gases used for etching and deposition of the low relative dielectric constant material. Furthermore, as discussed above, Xi discloses depositing an amorphous fluorocarbon film having a low relative dielectric constant using a fluorine source gas, but fails to explicitly disclose using a material gas containing C₄F₆. Moreover, Xi completely fails to disclose the object of preventing global warming by selecting a material gas containing C₄E₆, which has an extremely small global warming potential, from a material gas composed of fluorine and carbon to be used for depositing the amorphous fluorocarbon film. Applicants submit that Imai does not solve the deficiencies of Wang and Xi. Specifically, Applicants note that, while Imai may disclose etching an oxide film using C₄F₆, Imai fails to disclose or suggest depositing a fluorine-containing organic film having a relative dielectric constant of 4 or less using C₄F₆. Hence, independent claim 2 of the present application is neither taught nor suggested by the combination of Wang, Imai and Xi.

Claims 3-5 are dependent claims of independent claim 2 and hence should be patentable for at least the same reasons as well as for reasons of their own.

In accordance with another exemplary embodiment of the present invention, as set forth in claim 6, a method for fabricating a semiconductor device is provided. A metal film is deposited on a semiconductor substrate. A mask pattern made of a resist film or an insulating film is formed on the metal film. The metal film is dry-etched using the mask pattern to form a plurality of metal interconnections made of the metal film. Also, a fluorine-containing organic film having a relative dielectric constant of 4 or less as an interlayer insulating film is deposited between the plurality of metal interconnections and on top surfaces of the metal interconnections using a material gas. The material gas is selected from gases composed of fluorine and carbon and contains C₄F₆, of which global warming potential is less than 100, as a main component.

On the other hand, Matsubara discloses, as shown in Fig. 4, forming a metal layer (wiring layer) 103 consisting of Al-Si-Cu on a semiconductor substrate, forming interconnections by dry etching the metal layer 103 using a resist pattern, and depositing an amorphous carbon fluoride film 142 in which relative dielectric constant can be reduced to approximately 2, between and on the metal interconnections. Although Matsubara discloses various material gases, such as CF₄, C₄F₈, C₂F₆, and C₃F₈, as examples that can be used for forming the amorphous carbon fluoride film 142, Matsubara fails to explicitly disclose a material gas containing C₄F₆, as set forth in independent claim 6. Applicants note that, among the gases composed of fluorine and carbon, C₄F₆ is a more desirable gas to be selected as a gas having global warming potential of less than 100. Matsubara fails to explicitly disclose selecting such gas.

According to the embodiment of the present invention set forth in independent claim 6, C₄F₆ is selected from gases composed of fluorine and carbon because it can be used to form a film having a low relative dielectric constant and having a more superior adhesion to the underlying film, and at the same time prevent global warming during the deposition of the fluorine-containing organic film. Applicants submit that there is no motivation, absent impermissible hindsight, to select C₄F₆ as set forth in the present invention. Moreover, Matsubara does not appear to disclose or suggest the material gas being selected from gases composed of fluorine and carbon and containing C₄F₆, of which global warming potential is less than 100, as a main component, as now recited in independent claim 6. Accordingly, Applicants respectfully submit that, since Matsubara completely fails to disclose or suggest all features of the present invention, claim 6 is patentable over Matsubara.

Claims 7-10 are dependent claims of claim 6 and hence should be patentable for at least the same reasons, as well as for reasons of their own.

In view of the amendments and arguments set forth above, Applicants respectfully request reconsideration and withdrawal of all the pending rejections.

While the present application is now believed to be in condition for allowance, should the Examiner find some issue to remain unresolved, or should any new issues arise, which could be eliminated through discussions with Applicants' representative, then the Examiner is invited to contact the undersigned by telephone in order that the further prosecution of this application can thereby be expedited.

Respectfully submitted,


Donald R. Studebaker
Reg. No. 32,815

Nixon Peabody LLP
401 9th Street N.W.
Suite 900
Washington, D. C. 20004
(202) 585-8000
DRS/BCO